Docket No. 16026-[redacted]

RADIO FREQUENCY IDENTIFICATION METHOD AND SYSTEM OF DISTRIBUTING PRODUCTS

BACKGROUND OF THE INVENTION

The present invention relates to methods and systems for distributing products to customers. More particularly, the invention relates to a method and system that tracks the use of products using radio frequency tags and provides information to a central computer to enable automated restocking, inventory, tracking, or reordering of the products.

The Internet, EDI, and similar systems permit businesses and ordinary consumers to order goods. However, the delivery of those goods still depends on distribution systems that are based in the physical world. The science-fiction ideal of being able to instantly have goods pop out of a computer or to receive them through a "transporter" or some other device has not yet been realized, and probably will not for many, many years. Presently, consumers may have goods shipped via various overnight delivery services. One drawback of present delivery technology is that it is primarily paper-based. Orders are made on paper and delivery involves shipping invoices, receipts, and other paperwork, which is costly to handle and annoying to many people. Even with technology that is not paper-based, ordering and receiving goods requires a number of steps. For example, for a typical Internet order, a consumer must view the applicable Web site, select the item, such as by clicking on an icon, fill out an electronic order form, and wait for the product to be delivered. Regardless of whether paper-based or electronic technology is used, present delivery methods usually require that the customer or his or her agent be present at a physical location to take the delivery of the ordered product. Further, delivery is usually made to a loading dock or similar location. This requires some internal distribution system to deliver the goods from the initial delivery point to the location where it is actually needed.

SUMMARY OF THE INVENTION

Accordingly, there is a need to improve the distribution of goods so that consumers experience distribution of goods at a location proximate to where the consumer will use the goods without requiring paper or computer ordering. There is also a need for a distribution system that requires less user intervention and data input than existing systems.

The invention provides a system and method where a user need only find the product of interest and take that product. As compared to most Internet-based systems and methods, the invention is "clickless." In other words, the invention requires little or no manual input from users. The invention provides a system for distributing a plurality of products. Each of the products has a radio frequency ("RF") tag. As used herein, radio frequency means electromagnetic radiation that lies between audible and infrared radiation. Each tag is encoded with a unique identifying code. In one embodiment, the system is designed to be accessed by individuals possessing a radio frequency user badge with an identifying code. Alternatively, the system could rely on magnetic swipe cards, password systems, biometric devices (such as a retinal scanner, thumbprint reader, voice identification unit, or the like), or other systems for limiting access to authorized individuals.

The system includes one or more cabinets, refrigerators, similar storage units, (generically referred to as "micro-warehouses") or even secured rooms that are stocked with the RF tagged products and accessed by individuals through one of the mechanisms described above. In one embodiment, each micro-warehouse has a door that may be equipped with a lock (such as an electric actuated lock), an antenna or antenna array mounted on or in the micro-warehouse, a client controller coupled to the lock and the antenna, and an output device such as a light or display. Using a signal from the antenna or other input device, the client controller checks the identity of the individual accessing the micro-warehouse, such as by reading the code of the user badge. The output device is then activated to indicate whether the individual attempting to access the micro-warehouse is authorized to access the unit. If the code or other identifier matches stored records of authorized users, the client controller

opens the door and the user may remove desired products from the micro-warehouse. Once the user closes the door, the client controller performs a scan of the products remaining in the micro-warehouse to determine the identity of each of the products. The client controller then generates a message including the identity of each of the products or other message related to the products taken, and sends that message to a server. The server tracks product and user information automatically, that is, without relying on user input. In particular, the server tracks product inventory, customer usage, restocking, usage frequency, faults, micro-warehouse temperature, timing, and other information. The server also generates orders for products taken from the micro-warehouse by the user. The server can be programmed to automatically place those orders, with the result that the system is "clickless." That is, the system eliminates the need for the customer to re-order consumed items.

In addition to the features noted above, the system may also locate the position or presence of one or more specific products in a micro-warehouse by conducting a scan of the micro-warehouse. In this way, the system can sense a disordered state of the product in the micro-warehouse. For example, the system can detect whether all of the components in a kit product are in the relevant kit box. Further, a product scan can detect whether any product in the micro-warehouse has been recalled, expired, or is otherwise not suitable for use. Upon detecting such a product, the system refuses access to the micro-warehouse until an administrator removes the product or otherwise addresses the situation.

The invention also provides a method of distributing a plurality of products from a micro-warehouse. The method may include fitting each product with a radio frequency identification tag, positioning the plurality of products in the micro-warehouse, sensing opening and closing of the micro-warehouse door, scanning the plurality of products in the micro-warehouse upon sensing closing of the door to determine the number and type of products in the micro-warehouse, generating a message based on the number and type of products in the micro-warehouse, transmitting the message to a remote processor or server, and maintaining an inventory in the server based on the message.

The method and system permit up-to-date information to be provided to the server which, in turn, can be connected to ordering and manufacturing information systems to ensure prompt re-stocking of the micro-warehouses. The system can be designed with multiple levels of access. For example, multiple micro-warehouses may be located within a secure room and a user badge may be encoded to permit a user to access the room only, a limited number of warehouses in the room, or all the warehouses in the room.

As is apparent from the above, it is an advantage of the present invention to provide a method and system of identifying and distributing products. Other features and advantages of the present invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a schematic diagram of a system embodying the invention.

FIG. 2 is schematic diagram of the server and client controller of the system shown in FIG. 1 illustrating the architecture of the enterprise application of the server and the architecture of the software on the client controller.

FIG. 3 is an illustration of the flow of products and information in a distribution system of the invention.

FIG. 4a is a flowchart of the software's boot up routine of the invention.

FIG. 4b is a flowchart of the software of the invention.

DETAILED DESCRIPTION

Before the invention is explained in detail, it is to be understood that the invention is not limited in its application to the details of the construction and the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced

or being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

FIG. 1 illustrates a system 10 embodying the invention. The system 10 includes two servers (maintenance and commerce) 11 and 12 that create and maintain user lists, perform inventory, account, ordering functions, and monitoring functions, such as microwarehouse status, monitoring temperature and other faults. Servers 11 and 12 may communicate with a client (discussed below) using standard protocols such as TCP/IP, or other protocols over a network 13. The network 13 may be the Internet, a telephone network, a wireless network, power line carrier ("PLC") network, or combinations thereof. Servers 11 and 12 include standard hardware and operating system software (not shown). Running on top of the hardware and operating system software is a micro-warehouse ("MW") enterprise application 14. The MW enterprise application 14 accesses a profile database 15 that includes a registration module 16, an order history module 18, an account set-up module 20, and a stock request module 22. Each of the modules 16 - 22 is maintained for each client coupled to the server 12. The modules may be configured with web content designed to be accessible using protocols for the World Wide Web section of the Internet.

As best seen by reference to FIG. 2, the MW enterprise application 14 performs numerous functions. Broadly, the MW enterprise application 14 controls the arrangement of the RFID user badges (discussed below), manages communication sessions with clients connected to the server 12, maintains an inventory of products for each client connected to the servers 11 and 12, checks inventory of the MW and other local MWs before ordering a product, manages security of communications, provides system administration functionality, and monitors and maintains the health of clients connected to the servers.

The registration module 16 provides part of the inventory functionality of the server 12 by providing access to information regarding the location of clients

connected to the server 12. In the invention, the clients take the form of MWs. The registration module also provides access to information regarding sales persons assigned to a particular MW and identification numbers for each MW. The registration module 16 may access a MW database 24.

The order history module 18 provides a history of orders for each MW and product preferences for each MW. The account set-up module provides administrative screens for payment authorization, user information, and similar information. The stock request module 22 controls inventory replenishment based on usage and on specific customer requests and similar information.

The server 12 also accesses a commerce engine 30 that uses information received from the client to generate orders that are delivered to the manufacturing infrastructure (not shown) that produces products to be distributed using the system and method of the invention. The information may be used by marketing, customer relation management ("CRM"), billing, and other systems and functions. For example, the invention may be used in the distribution of life science research products such as enzymes, assays, cloning vectors, component cells, and the like. (Of course, a wide variety of non-biological products could be distributed using the invention.) The information provided by the server 12 is used in the manufacturing infrastructure to ensure proper production of products according to the demand for such products. As noted above, the server 12 may be coupled to a plurality of clients. An exemplary client in the form of a MW 35 is shown in FIGS. 1 and 2. While only one client is shown, the number of clients connected to the server 12 is limited only by the server's internal capacity and the capacity of the network 13.

The MW 35 may take the form of a refrigerated cabinet, a freezer, or other storage container. A secured storeroom, similar location, or other defined area could also be outfitted with a client controller and other components, as described herein, and be used to store products. As shown, the MW 35 includes a door 37, an electric actuated lock 39 and/or a proximity sensor 40, and an output device that may take the

form of audio device or light 41. Other output devices such as a voice synthesis device, a display screen, and the like may also be used. The MW 35 is configured with an antenna array 43. The antenna array 43 is coupled to a client controller 45. In one embodiment, the invention may include an antenna with two vertically polarized array antennas. The antenna 43 is an RF receive and transmit device which communicates with a transponder device or tag (discussed in greater detail below). In one embodiment, the tag is a passive tag and powered by energy from the antenna.

The MW 35 may include a specialized card reader 47 in the form of a magnetic card swipe device, an antenna, a fingerprint reader, or similar device. The specialized card reader 47 is coupled to the client controller 45 via a communication link 49. The MW 35 may also include an internal and ambient temperature sensor 55. If included, the temperature sensor 55 is preferably positioned such that it can sense the temperature of the interior of the MW 35. The temperature sensor 55 is coupled to the client controller 45 to provide temperature information to the client controller. Additional information may be provided to the client controller through optional input devices. The location of the MW 35 may be monitored by a global positioning system (GPS) device (not shown) plus inertial frame recognition for fine measurement and for interpolation between GPS satellite acquisitions. The voltage, frequency, and other characteristics of electrical supply lines may be monitored and provided to the client controller 45 by a power line monitoring device (also not shown). Additional input devices, such as cameras, microphones, sensors, etc., could be coupled to the client controller to monitor environmental and other conditions.

The client controller 45 includes software to carry out several functions. The software included on the client controller 45 may be better understood by reference to FIG. 2. As shown, the client controller 45 includes an operating system 60. The operating system 60 is dependent on the type of processor used in the client controller. Preferably, the client controller 45 is an X86 single chip computer controller with a compatible operating system. If desired, the client controller 45 may be a consumer grade device such as a Palm Pilot personal digital assistant or Packet

PC device, and modified according to the teachings herein. Depending on the hardware used, the client controller 45 may be configured with a graphical user interface ("GUI") to facilitate interaction between the system 10 and its users.

The client controller 45 also includes an I/O interface 62, which may take the form of an analogue-digital, digital-analogue converter, digital input/output (ADC, DAC, and DIO) interface. The interface 62 handles input from the electric actuated lock 39, input from the temperature sensor 55, output to the electric actuated lock 39, and input from optional monitoring devices such as the GPS and power line monitoring devices.

In addition to the interface 62, the client controller 45 may have two other modules: an RFID user sensing subsystem 64 and a radio frequency data collector ("RFDC") inventory interface 66. The RFID user sensing subsystem 64 handles input and output to and from the specialized card reader 47. The RFDC inventory interface 66 handles input and output from the antenna 43 and handles links or sessions between the MW 35 and severs 11 and 12.

The client controller 45 includes software (not shown) which may incorporate the RFDC inventory interface 66 that reads the RFID signatures from tagged products (discussed below) placed inside the MW 35. The software may be implemented according to algorithms disclosed in International Publication No. W099/45495 and International Publication No. WO99/45495, the disclosures of which are hereby incorporated by reference herein. The referenced publications teach identification systems that can identify a plurality of RFID tagged items using an interrogator. The interrogator sends signals from antennas and cooperates with passive, transponder RFID tags in such a way as to eliminate or reduce interference problems that are typically associated with reading RF signals from multiple devices. The system 10 could also be implemented with active tags, although presently available active tags need to be improved so as to perform in the temperatures that the system is expected to operate within and at roughly the same cost and power consumption.

Before the system 10 may be implemented, one or more RFID access badges 75 must be generated. Preferably, the RFID badges 75, as well as the other RFID tags (discussed below) are passive transponder tags such as the tags disclosed in the above-referenced international applications. Preferably, the RFID badges 75 are encoded with information from the account set-up module 20 based on digital signatures. In addition, it is preferred that the digital signatures encoded on the RFID badges 75 used by restocking services provide one-time access to a specific MW, and thereafter expire. The RFID access badges may be fixed on a carton of products 80. Alternatively, they may be delivered separately to the facility where the MW of interest is located.

The carton of products 80 includes a plurality of individual products 90 each with an identification tag 95. Each identification tag 95 may be the same as an RFID badge 75, except that the digital signature on tag 95 will generally not expire. In one form of the invention, each tag 95 has a 16-bit identification code and a 72- bit item identification code. The 16-bit identification tag may be programmed with information such as the manufacturer of the product. The 72-bit item identification code is used to provide descriptive information regarding the product such as serial number, product type, date, lot number, and similar information.

Once all the products 90 have been fitted with unique RFID tags 95, the products may be shipped in the carton 80 to a designated MW such as the MW 35. As shown in FIG. 3, the carton 80 is packed according to a fulfillment request that is based on either an initial order from a customer (not shown) or MW specific business rules followed by the server 12. The carton 80 may be fitted with RFID access badge 75 or the RFID access badge 75 may be shipped separately to the location of the MW of interest. If fitted with an RFID access badge 75, the carton 80 may be shipped by a delivery service contracted to deliver the package to the MW 35. Once the carton is delivered, the recipient or user may use the RFID access badge 75 to open the door 37 of the MW 35 by passing RFID access badge 75 in front of the reader 47. Client controller 45 reads the digital signature of the RFID access badge 75 and confirms

reading of the code by actuating a user feedback device such as a voice synthesis module or the light 41. Since, the server 12 provides a locally based user list to the client controller 45, the client controller 45 oversees authentication of the digital code read from the RFID access badge 75. Client controller 45 checks the authenticity of the read code by matching the code to the user list. Client controller 45 may then optionally read the temperature sensors 55 and transmit temperature information to the server 11. Preferably, the temperature sensor is also read on a periodic basis, with the temperature information being transmitted to the server each time the temperature is read. Client controller 45 can also be programmed to transmit temperature data if the temperature falls beneath or above a predetermined range. In many instances, it will be important to ensure that the temperature of the MW is within an appropriate range to store the products 90. If the temperature of the MW 35 is within an appropriate range, and the user is authenticated, the client controller 45 then actuates the lock 39 to open the door 37 (of course, the MW need not be equipped with the lock 39). If the temperature of the MW 35 is not within an appropriate range, then access to the MW may be prevented by maintaining the lock 39 in a closed state. This would allow a refrigerated unit associated with the MW to cool the interior space of the MW to a desired temperature before ambient air was allowed into the MW by opening of the door. This also provides for product integrity during power failure.

Once the door 37 opens (which may be sensed by the proximity sensor 40), a communication session between the MW 35 and servers 12, which may be segmented based on appropriate events to optimize user response and network usage, begins. Having full access to the MW 35, the employee of a carrier or logistic service who delivered the carton 80 now proceeds to place the individual items 90 into the MW 35. Once the carton of products 80 is empty, the delivery employee then closes the door 37, and removes the carton, if necessary. The proximity sensor 40 senses the closing of the door 37. The client controller 45 senses the status of the sensor. Preferably, the lock 39 (if used) resets automatically after being unlocked for a predetermined time, for example five (5) seconds. The user has that predetermined time to open the door. The RFDC inventory interface 66 is disabled once the door 37

opens. When the door 37 closes, the RFDC inventory interface 66 is enabled and initiates a scan of the products placed within the MW 35. Upon completing the scan, the client controller 45 sends a change-in-inventory message 100 to the commerce server 12. To ensure integrity of the inventory change billed to the customer, the client controller 45 employs an integrity algorithm when the RFDC inventory interface 66 scans the MW 35. The algorithm is based on statistical information, historical information, and other factors including RF algorithms (frequency-hopping, etc.) and delay data.

The MW 35 may be accessed by a customer at the MW location using a separate RFID badge 75 shipped directly to that customer. Alternatively, and as noted above, the reader 47 may be configured as a magnetic card swipe device, barcode, a fingerprint reader, or some similar device that controls access to the MW 35. Regardless of its exact configuration, the reader 47 reads the input from the customer and acknowledges reading of that input by lighting the light 41. The client controller 45 then sends an input signal to the server 12. The server 12 then conducts an authenticity review of the input. If an authorized input is received, the server 12 sends an okay message to the MW 35. The client controller 45 may have the capability to authenticate the review as well. Once authentication takes place, the client controller 45 then opens the door 37 allowing the customer access to the interior of the MW 35. The customer then removes one or more products 90 from the interior of the MW and then closes the door 37. Once the door is closed, client controller 45 scans the remaining products in the MW 35 and sends a message containing the missing products to the server 12. Identifying which products have been taken, the server 12 compares the previous inventory prior to opening, to the inventory of the missing items. From the comparison, the server 12 determines the missing items in the MW 35. The inventory information is then communicated to the commerce engine 30, which stores the information for future use for both marketing and inventory functions. Receipts for the used products can then be emailed or printed and shipped via regular mail to the customer at the MW location. Invoicing can also occur using electronic and standard mechanisms.

The inventory message can be used for other purposes as well. For example, the inventory message includes information regarding individual products. Therefore, the amount of time a particular product spends in any MW may be recorded by the server, as well as the product's temperature history. If this time is recorded, it is also possible to compare the amount of time any particular product spends in a MW to a shelf life for that product. Temperature history can also be stored and compared to other data. If the shelf life is passed, then an expiration message, such as a pick list, may be generated and sent to the MW or an e-mail address of a user of the system to inform users of products that should be removed from the MW and not used. In addition, the inventory message may be used to determine the type of products in the MW 35. If any of the products present within the MW 35 are subject to a recall, the MW 35 may be placed in a "lock down" condition, whereby access to the MW is denied until an administrator or other authorized individual removes the recalled product or otherwise addresses the situation.

FIG. 4a and 4b are flow charts of the software used in the invention. Once the client controller 45 is turned on in FIG. 4a at step 138, it executes a standard boot up routine at step 140. Part of the standard boot up process enables the software to automatically update itself. At step 142, a message is sent to the maintenance server 11 to query the current version of the controller software. If the version on the server 11 is the same as the version on the client controller 45, the client controller 45 establishes a wait state as shown in step 152. If the version on the server 11 is newer than the version on the client controller 45, then the newer version is downloaded over the Internet, as shown at step 144. The newer version is loaded into the alternative pocket or partition and written to flash memory, as shown at step 146. Then the software is booted, as shown at step 148. A garbage collection routine clears the old version. A message packet accompanies each boot to the maintenance server, including version status and operating status. Each boot then requests a reload of the list of authorized users from the server 11 at step 150. The list is then reloaded at step 151. As shown in FIG. 4b at step 152, the client controller 45 then establishes the wait state of the system by initializing various variables or objects such as a USER, MSG 1, MSG 2, CNT1, TEMP 1, TEMP 2, and SOLENOIDS. In addition,

the client controller 45 initializes variables or objects SWITCHES, POWER, and LIGHT. Once initialization is complete, the unit is ready for user access. During this wait state, the client controller 45 performs periodic checks on the status of the MW 35. When a customer approaches the MW and presents an RFID badge, the client controller 45 reads the user RFID badge at step 154 and checks the validity of the identification code read from the badge at step 158. If the code does not match a valid code, an invalid user message is generated at step 162. The message may be displayed on an output device (not shown). If an optional lock is installed on the door of the MW 35, the client controller 45 then opens the solenoids in the lock on the MW 35, as shown at step 166, if the code is valid. An internal timer is then started, as shown at step 170. In one embodiment of the invention, the proximity sensor 40 is used to detect opening of the door 37 and the status of the door. Once the door opens, the proximity sensor 40 switches its status. At step 174, the client controller 45 checks to see if the door has been opened by reading the status of the proximity sensor 40. If the proximity sensor 40 has not changed status, the client controller 45 will continue to check for a predetermined amount of time, as shown at step 178. If the predetermined amount of time is exceeded, the solenoids are closed (step 182), which locks the lock 39, a timeout error message is generated (step 184), and the client controller 45 returns to the initial state, as shown at step 186.

If the door 37 is opened within the predetermined amount of time (currently set through practice at five (5) seconds), a second timer is started, as shown at step 190. The client controller 45 then records the internal temperature of the MW 35 at step 194 and then checks to see if the door 37 has been closed at step 200. The client controller 45 continues to check for closing of the door for a predetermined amount of time, as shown at step 204. If the predetermined amount of time expires, a close door message is generated as shown at step 208 and steps 190 – 204 are re-executed.

Once the door 37 is closed, the client controller 45 closes the solenoids, as shown at step 212. The client controller 45 then confirms that the door 37 is closed at step 216 and performs an inventory scan at step 220. The data from the inventory

scan is then sent to the server 12, as shown at step 224. The client controller 45 then returns to the initial state (step 186).

In another embodiment, the system utilizes a defined area to enclose the tagged products rather than a cabinet. The defined area uses an access point to serve as its entryway. The products within the area are fitted with identification tags and specifically positioned in the area to be recognized by the RFDC inventory interface. Product scans begin when a sensor senses a user passing through the access point. The access point is controlled by a processor, such as the client controller 45, and is able to restrict access to the area and products, if necessary.

As can be seen from the above, the invention provides a method and system for distributing products. Various features and advantages of the invention are set forth in the following claims.